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APPLICATIONS OF SCIENCE

TO

HUMAN HEALTH AND WELL-BEING.

BEING

A LECTURE,

INTRODUCTORY TO A COURSE, "ON THE APPLICATION OF PHYSICS
TO COMMON LIFE," DELIVERED TO THE EDINBURGH
PHILOSOPHICAL INSTITUTION, IN JUNE, 1847.

BY

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&c.

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LECTURE I.—INTRODUCTORY.

PHYSICS (or Natural Philosophy) defined as referring to Solids, Liquids, and Gases—at Rest or in Motion; and to the great Natural Powers, Gravity, Heat, Light, and Electricity. Practical value of an accurate, or scientific, knowledge of these subjects. Assertion illustrated,—that there is an “Art of Living” distinct from the Arts of Production, &c., being the Application of all the available Resources of the world to the greatest possible Well-Being of each individual of the Human Family. This Art, sketched at first by vague experience, may be vastly improved through the progress of the various Sciences, both those that expound the outer World, and those that treat of the Nature of Man. Branches of Physics at present most fertile in contributions to the Art.

LECTURE II.—TUESDAY, JUNE 8.

HEAT. Its relations to the Health and Activity of the Human Body. Nature's modes of compensating for its Excess or Deficiency. Clothing. Warming of Houses.—WATER. Its uses as a medium of conveying Heat and Cold. Its Cleansing powers. Qualities to be chiefly attended to in selecting water for Common Use, or for Supplying Towns.—THE BATH. Discrimination of the effects it is understood to have on the Human System. Its various Forms. Its value as an Institution of Daily Life.

LECTURE III.—FRIDAY, JUNE 11.

AIR. Difficulties in the way of thorough Ventilation. Easy Contrivances for aiding it in Private Houses. Requisites for the Ventilation of Public Places.—ACTION AND REPOSE. Various States of the Moving Organs of the Human Body. Alternation of Work and Rest. Travelling, Locomotion, and Scenery. Furniture, Rooms, and Enclosures.

LECTURE IV.—TUESDAY, JUNE 15.

ACTION AND REPOSE, continued. *Gymnastics and Sports*: Essential Requisites for making these effectual. Institutions founded on them. Their value as means of Diversion and Recreation; as Bodily Training. *Speech*: An Activity governed to a great extent by the same laws as the other Bodily Activities, but of peculiar interest from its being part of the Machinery connected with Thought and Emotion. Loud Utterance, Reading, Thinking by Language; their Regulation and due Alternation with the total Rest of the Vocal Organs. Management of the Voice. —SOUNDS. Their Classification according to their Mechanical Origin. Their Direct and Indirect Influences. Control of Sound in Buildings.

HUMAN HEALTH AND WELL-BEING.

THE science of Natural Philosophy, or Physics, may be familiarly chalked out, by saying, that it refers to *Solids, Liquids, and Gases*,—to *Motion and Rest*,—and to the four great Natural Powers, that we term *Gravity or Weight, Heat, Electricity, and Light*. In speaking of Solids, Liquids, and Airs or Gases, as a branch of Physics, we have in view the causes and laws of the Aggregation of bodies,—the influences that make them solid, liquid or aerial, and determine them to have one kind of solidity rather than another; rendering them hard or soft, brittle or tough, elastic or non-elastic, crystallised or otherwise. Since all material substances, whether metal or stone, animate or inanimate, air or water, are made up of very small particles, surpassing in minuteness the finest dust or powder that we know of or can conceive, it is necessary that these particles should have the power of clinging to one another, in order to make such firm aggregates as the head of a hammer, the trunk of a tree, or a cable rope, or even to become a liquid mass, like water, which is a very different substance from the powder of water, as we see it in spray and in cloud; and although aerial bodies have no adhesion, they are just as different from powdery particles as the hardest solid is, being possessed of an active self-repelling tendency, which makes them spread out to the utmost limits that are allowed them.

The accurate study, then, of these attractions and repulsions which give to bodies the peculiar state of aggregation belonging to each, is included in Physical Science; and all the regularities that have been found out concerning them, when systematically stated, make up one of the branches of Physics, under the title of the *General Properties of Matter*; these properties being universal, or attached to all bodies that we know; that is to say, there is no substance in nature that retains at all times the powdery state; every material that the earth supplies has the power of being, either a compact solid, a slightly adhesive liquid, or a self-repelling gas, and most bodies can be any one of the three. The finest dust that is driven by the winds may fall to the ground, accumu-

late there and become coherent, till at last it forms a part of the solid rock.

There are other Properties of Matter besides these, other powers of Aggregation, which are not immediately connected with the three states of bodies. We have, for example, the *Chemical Aggregation*, which comes into play when two substances of entirely different character and appearance join together and make a third substance different from both; as when sulphur and filings of copper unite to produce a kind of material that is not like either, being black whereas they are yellow, and having neither the inflammability of the one nor the metallic lustre of the other. This is a power of vast range and importance in the world, since by it, we can obtain, from a few elementary substances, an infinite number of compounds, and each of them possessed of a different utility from all the rest. There is, moreover, the *Vital Aggregation*, belonging to matter that is also endowed with Physical and Chemical Aggregation, but not to all matter; it is much more special and exclusive than the two others. By it living beings are formed, whose peculiarity it is to keep up an endless flow of activity and change, who must either *grow* or cease to exist as living beings.

The only other states of matter that are termed Physical or Mechanical States, are *Movement* and *Rest*; which are subject to a very few remarkably simple laws, discovered in the 17th century by Kepler, Galileo, and Newton.

The great Natural Agencies that are studied under Physics, in addition to the Aggregating Agency, are, first, *Gravity*—or the common tendency of all matter to fall together from all parts of the world, according to one simple and uniform rule; second, *Heat*; third, *Electricity*; fourth, *Light*. Of these three last influences, all derived from the Sun, two, namely, Heat and Electricity, are now known to be the same agency acting in different situations; the third, Light, is peculiar and distinct from either, and being of a more subtle and refined character, seems to be superadded, rather than derived from the others.

It is difficult at first sight to discover any unity or family resemblance in the subjects thus classed together under the common title of Physical Science. Might we not as well take up Chemical Aggregation, and add Gravity and Light and make a science? Probably few people would see any more incongruity than in the collection of heads that we have been mentioning. There is, however, a real unity and family connection, which may be stated thus:—The three states of matter are under the control of Heat; by raising the temperature, solids may be changed into liquids and gases, and by cooling, gases may be made liquids, and liquids turned into solids. Again, the actions of Electricity and Light upon bodies depend upon their mechanical aggregation in the first place. And Gravity, Heat and Electricity, all tend to produce movement in bodies, or to resist movement; they are in fact

mechanical prime movers, and their effects are best exhibited in the production of mechanical force. So that each branch hangs upon every other in the way of dependence ; the nature of motion and mechanical force precedes the study of Gravity, and the attraction of Gravity is naturally followed up by the attractions that aggregate particles into masses, which necessarily leads to the consideration of the great counteractive of cohesion, Heat ; and Electricity and Light require us previously to understand all these

With the exception perhaps of Electricity, the things studied in Physics are the most familiar objects in Nature. We are supported, surrounded, and acted on in every way by solids, liquids and air ; we are always cognisant of rest and movement ; and Weight, Heat, and Light are constantly present among our feelings. Through these influences we have to pilot our existence every moment ; they hold the issues of life and death, weal or woe. We cannot help knowing something about such agencies, and the general course that they take. We must be aware that the falling rock will crush us, the unstable water give way beneath our feet, that the stormy wind will sweep away the ill-built dwelling. In fact, a certain degree of knowledge of the Physical Agencies is obviously part and parcel of the practical wisdom of the human race. Self-preservation and the various handicrafts are dependent upon this knowledge, and improve as it improves. We are all Natural Philosophers, though few of us may be good ones. The subject, with all our opportunities of knowing its processes, is very abstruse and difficult. Some of its operations cannot be seen by the human eye ; some put on false and delusive appearances ; some are contradictory ; so that, notwithstanding the necessity we are under of knowing such things, we never would have come to the exact truth regarding Gravity, Heat, Solidity, Fluidity, &c., had not the search into them been made a craft, distinct from all other crafts, employing a separate class of men selected for their high intellectual power, and gradually acquiring a set of machinery and methods peculiar to itself. The art of reaching the true secrets of Nature, of obtaining such exact information about its workings as will never deceive us, is a very laborious art, improved from age to age, and containing in its workshops a more extensive array of tools than almost any other. It is by telescopes and microscopes, chronometers, balances, thermometers, barometers, electrosopes, and prisms—by inductions and deductions, experiments and verifications, by scientific journals and learned societies,—that what we call the *scientific* knowledge of Physics has been gained, which differs from the common or unscientific knowledge in being certain where it is vague, and in being ten thousand times more extensive. What we would never have known by unassisted observation, is clearly revealed through the scientific method. Who could have told us the speed of a ray of light or the weight of the moon by their naked human faculties alone ?

Now it is from the knowledge acquired, in the artificial way, by the knowledge-seeking profession, that we have lately been deriving such immense improvements in the industrial arts. The Steam Engine was brought to perfection, not through the ancient experience of mankind regarding Heat, but through the careful investigations of a few individual men with the requisite tools and faculties. The astonishing power of our telescopes and optical machinery could not have paved the way for improved Navigation, if Newton, and one or two others, had not studied Light in a very different way from ordinary mortals. And the splendid train of novel facilities, opened up in human life by the application of Electricity, are the results of pure scientific inquiry, accomplished chiefly within the last two generations.

We may therefore say that there are two great stages in the progress of the various arts and productive occupations of human life. The earliest set of devices are derived from men's ordinary and unassisted observation of the usual course of nature. The methods of mining, building, ploughing, sowing, spinning, dyeing, metal working, carrying from place to place, navigating, and so forth, are got at after trying many different methods and implements until it is seen that some answer better than the rest; these being once approved of are then handed down to posterity, and they may often remain unchanged for a long course of ages. In fact, unassisted reason soon comes to a stand-still; as we see in such nations as the Hindoos and Chinese, who have never reached scientific methods of acquiring a knowledge of Nature. The *second* stage of progress is entered on, when, by the perfection of the knowledge-seeking art, the hidden laws of things are brought to light, and a vast number of additional properties discovered in the various objects of the world; when, for instance, by looking into the composition of vegetable bodies, and into the matters making up the soil that nourishes them, we can specifically and exactly suit the one to the other, instead of depending on a vague experience of gross results. On this second stage the European world entered last century, in regard to the mechanical arts; so that, in fact, we are only *beginning* to develope the vast resources of our planet, and we have now to look forward to a long and unremitted series of improvements.

But I must next call your attention to the difference between the *Arts of Life*, and the *Art of Living*,—or between man's powers in farming, building, manufacturing and trading, and his ability to apply the results of all these to his own life and well-being; for this is the final intention of such manifold labours. Because we have very much improved the Arts of Life, it does not follow that we have equally improved the Art of Living. We may increase our abundance of the things that are useful and good, without acquiring the skill to apply them in proper measure, and in well-timed arrangement to the highly complex structure and

constitution of our living framework. There is even not a little ground for the insinuation that the multiplying of good things, or really beneficial agencies, is dangerous to our life, instead of helpful; such is the difficulty of rightly applying them to their proper uses.

It is, beyond all question, desirable that each one of us should contrive our arrangements and daily ongoings so as to make the very most of life; to render our existence as rich and effective, and great and brilliant, as it can be made; to combine the choicest enjoyments with the most wide-ranging and beneficial activity. Our own nature prompts us to do all we can to prevent pains, distractions, irritations and terrors from oppressing our daily career. Moreover, we have to make sure, never to compromise the future by the present; that the strength and vigour of the morrow shall not be exhausted by the business or pleasure of the day. We need to learn to avoid all *avoidable* evil, and to support ourselves under the *inevitable* burdens of life. Now it is only by knowledge and skill going along with adequate force of resolution, that we can so use the resources of the world on the one hand, and so control the impulses of our own nature on the other, as to maintain the highest possible pitch of vitality, and cause a constant current of our finest emotions and activities. In possessing the command of our own existence we have a lordship or a kingdom, if we would so consider it; for it may well employ the highest gifts of a ruler to govern it well; and if we run it to wreck and perdition, great is the fall thereof. If our life go constantly halting and stumbling, if something about us is incessantly going wrong, if our Present is constantly uneasy and our Future frequently broken up, if we have neither enjoyment nor hope, if we are disappointed by all events,—it is plain that our existence is constructed in some fatal mistake, and that we are altogether out of harmony with the eternal laws of things. It would be rash to say, that any man might be happy and useful if he knew how to set about it, and were possessed of an ordinary degree of determination; but there is no rashness in declaring that a vast mass of human ills could be avoided by a more intelligent arrangement of the scheme of life. It is a great misfortune to come home at night weary and worn, and in our ignorance, to resort to what makes us worse rather than better; to unstring our nerves in the hour when courage and hope are required of us; or to distract our energies when they behove to be combined for a mighty effort.

The Art of Living, therefore, is the method of stretching out the resources of the world to the measure of human wants, desires and capabilities. Each person has to consider his own peculiar situation and framework, and to select from among his possessions and opportunities, what will do most to yield him a grand and beautiful existence. We have all a certain command of what supports and gratifies body and mind; we have our homes, our

city, our companions, our books, our means of accomplishment and instruction, our walks and excursions, the face of nature, the inspiration of art, the ongoings of the world, and many other things capable of influencing us to our very inmost being ; on the other side, we are liable to burdens and toils, to violent shocks and slow miseries, to weariness and depression, to temptations and failures ; and it becomes our task to dispose all these things to the making our lives joyous rather than grievous, powerful and benignant, rather than empty or hurtful. We require to adjust ourselves to our situations, and, if possible, to get rid of contradictions and incompatibilities ; to avoid attempting what is above our powers, to strike the balance between desire and gratification, and to observe the limit that our strength has placed to enjoyments and pleasures. And if such a reconciliation be difficult, there is the more need that we should know of all the help that lies within our reach, and learn how far the good ordering of our daily and yearly life may be made to go towards rendering it harmonious and happy.

Considering the boundless variety of human conditions and human characters, it looks at first sight a very hopeless business to construct an Art of Living, or a set of comprehensive maxims of Life-guidance, that shall be useful to every one and injurious to no one. What common prescriptions can be given to a man of pleasure, and a man of ambition, to giddy youth and sedate old age, to a man struggling and a man victorious, to opposite temperaments and constitutions, to the recluse and the lover of social fellowship ?

Now it is perfectly true that the method of regulating each individual life cannot be exact without taking into account the character on the one hand and the worldly situation on the other. And hence if ever our literature shall possess a perfect system of Life-guidance, it must specifically allude to all the great varieties of human character and human conditions. But there is such a very great similarity in man's nature in spite of all distinctions, and the outer world presents so much that is the same to every one, that we have room in the first place for a set of rules fitting to all places and times and to every member of our common race. There is an anatomical and physiological identity in our frames ; the earth, air and water, light and heat, seasons and vegetation are common to us all to an extent greater, I may say, than the whole range of difference that separates man from man. And so far as this similarity holds, we may have a set of universal doctrines for regulating our lives to the best advantage. And as these universal doctrines have not yet been found out, except in a very imperfect way, and still less diffused and made known in the world, the complete science of Living, founded upon individual peculiarities, must be waited for.

To see how much there is common to all men in the necessities and requirements of life, apart from the obvious wants of food

and shelter, and sleep, let us reflect how extensive and ramified is the need of *support*, strength or vigour in every human condition whatsoever. There is hardly anything that any human being does, —whether it be to work or play, to think or enjoy pleasure, to give or receive, to love or hate, to serve or command—that does not tend to exhaust something about the human system, to bring on some weakness or weariness. Although the varieties of exertion are innumerable, the fatigue falls upon nearly the same organs, and the modes of refreshment and sustenance, and the cautions to be observed, are almost alike for all. The same nerves, the same flesh, the same stomach suffer from over-excitement, whether in business or in pleasure. Men may be laden in many ways, but the counteractions and props, if we knew them, are very similar for all cases. Here, therefore, is one foundation for a general Art of Living. How valuable it would be to ascertain precisely all the things that can minister to the support of the human frame under fatigue, so that each one might apply to his own case, whichever of them he could command! It is well known that a small increase of bodily vigour will often suffice to disperse a whole crowd of irritations and annoyances, and to renovate the entire tone and colour of the thoughts.

In like manner if the Art of Living were rested on a scientific and systematic basis, it would have to enumerate the various causes of depression and exhaustion, not merely the obvious influences known to every one, but many that are utterly unsuspected by most people. We should thus know to avoid all of them that are not involved in our indispensable duties. So a full and detailed exposure of the whole class of false stimulants, opiates and undermining excitements, would be a treasure of wisdom to the whole human family. That we are as yet unpossessed of this acquisition is apparent from such facts as the unsettled question regarding the use of alcoholic drinks.

Life has often been compared to a drama, with its passions and incidents, its cross purposes and uncertainties, its display of character in trials and in triumphs, its momentous issue either in tragic ruin or in virtue rewarded. It may also be compared to a melody, when each state of being is in fine accordance with what went before it, and what comes after—when there is unity, consistency and character in the whole—when the various strings of our complex nature are touched in harmonious succession with the due observance of intervals and time. To bring about such a musical flow of existence is worth striving for; and the knowledge that will in any way aid our attempts is indeed more precious than rubies.

I have already said that the Art of Living is quite distinct from the various Arts of Production, although these must in general be determined by what is useful to man. But it is distinct also from the Arts of education, social and moral duty, and religious obser-

vance. It no doubt links closely with these. It must, for example, often prescribe things to be learned or acquired, and thus interfere to control education. It is necessarily subservient to our duties, and should aid us in the fulfilment of them. But still it has a field exclusively its own ; its purpose is peculiar to itself, and the knowledge that it proceeds on is a distinct branch of inquiry. It is Prudence enlarged so as to include the uttermost compass of our being. Bodily preservation is the primary department of it ; the highest possible range of mental elevation and power, rendered consistent with tranquillity and enjoyment is its highest end. It is, in fact, Wisdom, in the sense most universally understood in all countries and times. The lower animals have this art for the most part included among their instincts. We too have instincts, some of an inferior, and others of an elevated order, to guide us a certain way. But our chief monitor is experience, or repeated trials, conducted under the guidance of our rational judgments, which lead us to adopt or reject, according to the issue of, each various scheme. In this way a great store of useful facts and maxims have been accumulated and handed down through the successive generations of man. We have our proverbs, our advices, our wise sayings, the established usages of families, parental instruction, the admonitions of the aged and the learned. We are duly told to labour diligently at our callings ; to control our passions ; to acquire useful accomplishments ; to be regular in our mode of life ; to lay up store for the future ; to be content with what is allotted us ; and we are introduced into the games, pastimes, and recreations that exhilarate human existence. We find institutions and manners set up in the world with a view to gratify and improve our lives, and we are taught to take our part in working under them. There is no lack of devices for sweetening the flow of man's earthly career ; and these have actually accomplished their end, with a degree of success that would astonish any poor creature launched naked into a primeval forest to act out his drama of life there. Why, then, should not all this suffice for us ? Is not the experience of a hundred generations, with all the helps they have received, enough for their posterity to the very end of time ?

We answer, No ; and that because of the fact already alluded to, that the experience of the natural unassisted reason can never discriminate nicely the good and evil agencies that beset our being. Although the earth had been as large as Jupiter, and the duration of man a million of ages, the problem of a highly refined existence to be attained through ordinary resources, would have been as far from its solution, except by first developing the difficult art of natural investigation, and through it extracting the secrets of the most hidden workings of the world.

But that the Art of Living has not yet come to great perfection is testified by the deplorable experience of the human race. The per-

plexity, and discord, and difficulties of life have been the theme of complaints that ring through all the ages of men ; yielding Cynic and Stoic philosophies, self-inflicted tortures and immolations, voluntary banishment from the world, gloomy speculations, suicides and crimes. It is surely worth while trying whether a better knowledge of the actual course of things, and of the beneficial agencies wrapt up in the womb of nature, may not help, among other causes, to stem such a torrent of despair, and prove the possibility of a great and harmonious existence for man.

For this end we are anxious that the Art of Living should be based, not as heretofore, upon vague experience, however extensive, but on the well-sifted and thoroughly tested experience that constitutes our Exact Sciences. And it is a satisfaction to know that several of these sciences have already yielded important contributions to this great practical object. Some of these contributions I shall take the liberty of referring to, to exemplify the nature of such applications, and to introduce the specific case that I am to dwell on in the subsequent lectures.

The *Arithmetical* and *Mathematical* Sciences have now reached, as you may have heard, an amazing perfection, and they carry their usefulness into all the arts and ongoings of life. They have also been valuable to the specific Art of Living. Even the small range of arithmetic requisite for enabling each person to balance their means with their expenditure, fulfils an important function. But the most notable application of mathematics to our present case, is its serving as the foundation of, perhaps, the greatest device for improving the tenure of human existence that modern ages has produced ; I mean the system of insurances as now practised. This wonderful instrument for alleviating the load of human cares, and quieting feverish terrors and sleepless nights, could not have been set up until the Greek had perfected his geometry, till algebra had come from the Arabs, and Napier of Merchiston constructed his logarithms.

Reserving my allusions to *Physics* to the last, let me mention next the science of *Chemistry*, so new, and yet so comprehensive and so certain. Besides creating entire new fields of industry, and multiplying the diffusion of useful commodities, this science first explained to us exactly our dependence on a pure atmosphere, and specified the change that comes over the air in passing through our lungs. The settled indifference of the human race to such a prime element of existence as fresh air, proves how long it would take to perfect even our bodily condition by the experience of the general multitude. The immortal discoveries of Priestley, Lavoisier, and others, on the different kinds of air, took the lead in the movement that is now beginning to operate for improving the dwellings of the present generation. Chemistry is also commencing to explain the laws of digestion ; from which it will gradually proceed to render an exact account of all the changes

connected with the absorption and expulsion of material substances from the human system. The arts of eating, drinking, and cookery, universally associated with living well, will one day owe their perfection to this beautiful region of scientific truth.

The science of Animal *Physiology* ought naturally to be the most fertile in applications to the art of maintaining high bodily vigour and enjoyment, seeing that it is the principal foundation of the art of healing; and this will certainly be the case when it is farther advanced. It is itself, however, a complex science, requiring not only a specific and laborious investigation, but also the assistance of physics and chemistry in their most perfect state, to make it all that a science ought to be. But even as it stands at present, it has made some very valuable contributions to our art. It has pointed out the relation of the different organs of the human body to one another, as, for example, the connexion of the muscular system with the nerves; of the stomach with the skin; of the heart and the head. We are thus taught how we can act upon one organ through the medium of another. We may affect the stomach by purifying the skin; and, by regulating our motions and activity, maintain the vigour of the circulation and the clearness of the brain. This allows us a choice of resources in supporting the weaker parts of our frame; he that cannot eat and drink as he ought, may bathe, or walk, and by such means save his constitution from impending wreck. Physiology also explains the great doctrine of the alternation of the exercise and rest of the different functions of the body, which is, perhaps, the most comprehensive of all the conditions of health and well-being. The writings of Dr. Andrew Combe have diffused widely in this country a considerable knowledge of such applications.

Mental Philosophy, professing as it does to expound the peculiarities and proceedings of the human mind, ought to abound in useful applications to the art of existence. As Physics, Chemistry, and Physiology have to teach us all the sources of strength and support of a material kind, the science of mind ought to point out clearly all the supporting sensations, associations, and emotions, as well as all that are annoying and hurtful. This has not yet been done in a way to be practically useful. But there are many important maxims that owe what clearness or distinctness they have, to the labours of the few scientific men that have as yet applied themselves to the study of the mind; for example, it is ascertained that the happiness and satisfaction of a human being may be directly secured, by gratifying his strongest sensibilities and tastes on the one hand, and on the other by giving full scope to the exercise of his greatest powers and capacities; that is to say, *passively*, or by what he feels most, and *actively*, or by what he can do best. This is a general doctrine, which would, if carried out, very much simplify a great many of the questions and proceedings of daily life. The general experience of men has made

them always in some degree aware of facts falling under this principle. We are accustomed to speak of a person being in their *element*, when they have their finest and favourite susceptibilities gratified, or when engaged in the pursuits that bring out their highest capabilities ; but the comprehensive statement of the principle, simple and almost obvious as it may seem, could not have been arrived at without careful and exact inquiry.

The doctrines relating to congregated human beings, or masses of men living together in societies, including the principles of government, law, social duties, political economy, and civil history, have been proposed to be consolidated into one great branch, to be termed the *Science of Society*, or social science, to follow up the science of the human mind, which very much restricts its attention to the individual. Much good would arise if such a science were to attain any degree of certainty or precision. The society that we live in influences our life as much as the light of heaven, or the air we breathe ; and an exact appreciation of the effects of all our varied contacts with the world of human beings, is as desirable as to know the virtues of what we eat and drink. We are liable to be very much mistaken in our judgments of the good and evil we derive from companions and societies, from being masters or servants, teachers or scholars, the givers or receivers of benefits, from mixing with the multitude, or retiring to solitude. The action of society upon the individual is mixed and complicated, beyond the power of ordinary sagacity to unravel. And yet if it were explicitly defined, there is nothing in the whole range of the sciences that would be more useful to them that are desirous of sound guidance to their lives. Our sympathies, affections, admirations, and general enthusiasm, in the presence of our fellow men, are of unbounded effect in elevating and widening the current of existence ; but, besides that, in this mixed world, the opposite emotions of hatred and antipathy occur to depress and irritate the spirit, these very enlivening influences have their evils and their drawbacks, and it would take more knowledge than we have yet acquired of human nature to control them to our greatest advantage. It is even a disputed point on many occasions, how far the assistance that we receive from others in getting through the labours of life is for our good ; as in the matter of education, and in taking care of ourselves generally. There is, therefore, much need for introducing the accuracy of scientific determinations into this important region of human knowledge.

But my present intention leads me to confine myself to the applications that Physical Science is now capable of affording, to the full and healthy development of human life. I have stated that this science comprehends the laws of the aggregation of bodies into solids, liquids, and gases—the laws of movement, rest, and resistance to movement, commonly called mechanics—

and the doctrines of the four powers, gravity, heat, electricity, and light. Some of these branches have attained a very high degree of perfection, and every one of them has been applied, more or less, to improve the industrial arts. Several of them have also been highly useful to the art we are now discussing. For example, *Mechanics*, in the hands of scientific men, has furnished our modern timekeepers, and made their construction so simple that they have come to be distributed over the whole face of civilized life. Now, besides facilitating the business of society, these timekeepers are a very great help to our individual existence. They mark out the divisions of our day, and the alternations of our employments, with rigid accuracy ; rendering us independent of the illusions of our own feelings in knowing when to work and when to rest, when to eat and when to sleep. They are the handmaids of reason in controlling our life ; and we ought to feel grateful for a power, out of ourselves, and infallible in its indications, serving to keep our actions right. But we have other physical machinery with a like function, although only beginning to be introduced for such a purpose. Thus, there are thermometers, for determining the warmth of our rooms, and to put down for ever the petty contradictions that are constantly arising within doors, from the uncertainty of the naked sensations on such a point. To these we may add hydrometers, for ascertaining and enabling us to adjust the moisture contained in the air ; which is, next to warmth, the most important property of the atmosphere. The barometer, also, with its aid in predicting the weather, will often save us from the mishaps that spoil many a day's expected enjoyment. The common tendency of all such machinery is to compose to a great extent our inquietudes, and our fears that things about us are not as they ought to be, and thus to do away with one small portion of the evils of existence. Another class of mechanical applications includes the whole range of the movements, rest, resistances, and pressures of the human system, considered as a piece of moving mechanism, which it is to a great extent, and in that capacity expends and acquires a large portion of its vitality. This is one of the departments to be fully treated of in the present course.

The complete knowledge of the influences of *Gravity*, in making every kind of matter, solid, fluid, or air, fall down to the lowest place, and press with energy on all that is beneath it, has led to a vast addition of insight into a great many things. Some of the facts have been known in every age, such as the fall and pressure of solid and liquid masses ; but the gravity of the air that sweeps over our heads was found out by scientific inquiry alone. Now this last is a fact that bears upon our existence in various ways, and reveals a number of things important to our welfare. For example, as the weight of the air on high grounds is less than on low, its action on our system is

varied by our ascents and descents from one elevation to another ; and as it is almost certain that this difference of pressure is one of the changes that promote human health, like the alternation of seasons, we derive a good scientific reason for occasionally living on a higher or lower situation than our usual residence, apart altogether from the consideration of scenery.

The laws of the *Aggregation of Matter* form at present the most imperfect branch of physics, and this imperfection is a drag upon our progress in other departments. But, nevertheless, what we know has contributed to advance our information on several points connected with the agencies of health, as in all that relates to cleansing and purification.

The subject of the subtle agency of *Heat*, whose strange ways of working have been completely laid open within the last sixty years, by efforts of genius that do honour to our common nature, can never be separated from the consideration of bodily enjoyment and vigour ; and to it we shall devote the greater part of next Lecture.

The two remaining subjects of Electricity and Light have not as yet made very decided contributions to the Art of Living, although the agencies that they treat of are probably as influential on our being as any we have named. Both have received a high cultivation, and have yielded memorable improvements in the operative arts : but the action of influences, so very subtle, on the human constitution, has not been traced with scientific certainty. The laws of the passage of *Light* through crystals and transparent liquids, its reflection from mirrors, and the various zigzags of its career, have all been determined with precision ; but the effect that it has when it is finally buried in any one surface nobody at present is able to divine. All that we know of its action on our own frame is derived from our inward feelings ; and if these are more nicely discriminated by one man than by another, it is by the painter and the poet, and not by the natural philosopher.

The science of *Electricity* is so very recent in its great developments that there has hardly been time to study the various influences of this agency on the animal system, which is necessarily the most complicated case. But we are rapidly approaching to know the manner that it connects itself with human vitality, as well as to specify the effects of the different electrical states of the atmosphere upon our bodily condition. Being already provided with machines for producing the excitement to any amount, we shall probably very soon be able to apply these to counteract the hurtful states of the surrounding air, and to assist nature in maintaining the electrical tone that is in keeping with our highest pitch of vitality and vigour.

Extract from Lecture Second.

THE BATH.

THE first and foremost utility of the Bath lies in its cleansing power. The pleasantness, the healthfulness, and the beauty of a pure skin, are of themselves a sufficient reward for the copious application of water to the human body. A severe climate, an impure atmosphere, the clothing too seldom changed, and other circumstances, make the demand for frequent washings and ablations still more imperative.

But, in the second place, the bath in every form largely involves the actions of heat and cold on the system. I have already remarked, that water is the best vehicle that we have for communicating heat in great quantity, without being of scorching intensity ; and it is, of course, equally powerful in taking off heat, or in imparting cold. By applying this consideration, along with the principles previously laid down, as to the peculiar effects of heat and cold on the functions of the body, we shall readily understand the functions of the different kinds of baths, and on what occasions each should be resorted to.

First, with regard to the *Hot Bath*, or the infusion of a large quantity of additional heat into the body, we know this for certain that it allays the energy of the breathing and other respiratory functions, whose office it is to supply the system with heat according to its necessities. But to reduce the breathing is to diminish the active functions generally, or to lower the tone of activity throughout the whole. The abundant communication of warmth weakens the system by taking off one great stimulus to action. When the respiratory process is superseded to some extent, and rendered slower in its motions, the other members are, as a necessary consequence, rendered more languid in their motions. If a person has wrought himself into a highly excited active state, as by rapid walking, or other violent exercise, the hot bath reduces the excitement, and puts the frame as it were into a slower pace. It is thus beneficial in moderating an excess of active excitability, and may therefore be used in emergencies, with a view to keeping the exertions within the measure of the strength. When any one kind of exercise has been kept up for a great many hours, there is often a tendency induced, to continue or persevere in it, after the strength has been more than exhausted ; and the system, although in need of repose, becomes incapable of subsiding into the resting state. In this case, the hot bath may sometimes serve to arrest the current of morbid activity, and bring on the quiet that is in keeping with the exhausted condition of the frame.

We know still farther, in regard to the heating bath, that it vaporizes the water in the body, and causes it to pass off by the pores of the skin and the lungs, carrying with it certain of the waste matters of the system. It thus relieves and lightens the various organs in much the same way as a fire is quickened by clearing out the ashes. We have not merely a cleansing of the skin, but also a purification of the interior, after which the vital functions go on much brisker.

These two principles,—the quieting of a morbid or excessive activity, and the causing of a copious perspiration and clearing out of waste matter,—may be useful in assisting our judgment in the application of the hot bath. Its most direct and obvious utility, is in the case when the body has been exposed to a long-continued cooling influence; as on a journey, or by sitting in a cold or damp room. To betake one's-self to a fire after such an accident, is to mistake altogether the character of the case. Long before the system can be penetrated by the heat of the fire, it may fall into a settled derangement that it will take weeks to recover from. The hot bath is the true and natural remedy.

The difference between the *hot-water* and the *vapour* bath is, that the last has a far greater heating power. The steam condensing on the skin gives out all its latent heat, which makes an enormous addition to the other heat, but yet does not raise the temperature so as to scorch. The vapour bath is the favourite in cold countries, as in Russia, being in fact the greatest heating influence that we know. It enables one to lay in such a stock of heat, that a great degree of cold can be endured after it, provided the languor, induced on the respiration, is dissipated by taking a cold dash at the end of the operation.

If the *Cold Bath* were merely the opposite of the hot bath, it would in most cases be a slow murder; for the taking away of a large quantity of heat from the body is what we can rarely afford. But its great power lies in stimulating the respiratory apparatus to produce internal heat; so that it has really a *heating effect*, combined with *another effect*, namely, to increase the spontaneous vigour of the organs that purify the blood and keep up the circulation, and through them to quicken the vitality of the whole system.

The cold bath is thus the most energetic of the two: but more caution is requisite in using it. We have already seen, that a vigorous, active, robust state of the body is needed to sustain this secondary effect on the lungs and the breathing; and also that the sensation should be sharp and keen, as in the shower bath, or in the plunge into very cold water. An intense shock of brief duration is the least dangerous and most efficacious mode of applying the cold stimulus.

The extensive bathing system of the Roman and Oriental nations was founded essentially on the Hot Bath. It seems re-

served for our own times to develop the vast powers and properties of the cold application.

But besides the cleansing of the body and the administering of heat and cold, there is a third action of the bath, resulting from the rubbing, scraping, and shampooing of the skin, especially in the parts where there is any depth of flesh. We by no means appreciate the effect of hard friction by the use of towels, brushes, or horse-hair, when we speak of its agency on the skin alone: the great and essential influence is on the whole fleshy mass down to the bone itself. There is a good deal of complicity in this action, but some points about it seem very plain. In the first place, all rubbing and pinching has a tendency to squeeze the muscular mass very hard, and, as it were, to wring the blood out of it. But since the blood can move only one way, that is, out of the arteries through the small tubes into the veins, all such pressure must inevitably quicken the local circulation; in other words, it will increase the amount of pure blood brought to the parts, and hasten the departure of the impure blood, which is essentially a vitalizing and healthy action. But I am disposed to think also, that the squeezing of the muscles is a stimulus to their own proper action, or causes them to contract and put forth some portion of their energy; in fact, giving them exercise at the same time that they receive an increased supply of blood. Just as the circulation is quickened independently of the force of the heart at the centre, so the muscles are put in action apart from the ordinary nervous stimulus. Now this may be said to be an important variety of exercise; it is a kind of action that costs the nervous system almost nothing. It has, therefore, a great advantage over the usual forms of muscular exercise, such as walking, and may often be substituted for these; or at all events, it may be alternated with the other kinds, and have a very beneficial effect.

A fourth ingredient in the ancient bathing process was the oiling of the body; which is fallen into disuse with us, and needs not be resumed. It served partly to protect the skin from the high temperature of some of the bathing rooms and from the rays of a scorching sun, (for which reason probably it was a practice of the naked wrestlers), and partly to give a glossy hue to the body; it was also a means of perfuming the person. I know nothing really desirable for us in the oiling operation, that cannot be far better accomplished by the modern article of soap, whose action on the skin is never injurious; and which, therefore, should never be stinted in any cleansing or bathing application.

Baths then ought to combine in a high degree of efficiency, the three properties of cleansing, acting on the heating system of the body, and invigorating the muscles by rubbing and pressure. As it is beyond my province to allude to the treatment of positive disease by bathing or any other agency, I may lay it down as a maxim that, in general, the cold bath is to be preferred to the hot.

The hot bath is indispensable for many particular occasions, and there are times when the cold application would be improper ; and these occasions can be judged of, on such principles as I have already laid down ; but for regular use by healthy persons, attending to the requisite precautions, the cold system ought to be adopted. And in all its forms, whether in merely washing the body from a basin, or in using a plunge, or shower, or laving bath, the three different acts necessary to the complete operation should be faithfully observed ;—the rubbing in of an unstinted supply of soap, the cold water application, and the hard squeezing of the flesh. The rubbing should be administered in as many ways as possible, partly to increase the effect, and partly to diminish the fatigue of the arms, which feel a relief from every new kind of pressure, or touch. The use of the soap gives one form of friction, the drying towel makes a second, and to these we may add, if we choose, the horse-hair glove, or adopt a scraping tool, like what was employed in the Roman baths. And since this shampooing is a method of muscular exercise, it can be regulated in amount according as we feel the need of exercise, or are precluded from taking it in other shapes.

Next to eating and sleeping, the Bath, as thus defined, may be ranked among the very foremost of the necessities and supports of life. It is of far higher consequence, and of more general utility, than any kind of manual exercise, gymnastic, or sport. It affects the system more powerfully than these, even in the very points wherein their excellence consists ; and it is applicable in a thousand circumstances where they are not. It does not supersede, but it ought to come before these other practices. A place should be therefore found for the Bath among the regular occupations of life ; it ought to be a permanent institution, ranking immediately after the prime necessities of our being. Either daily, or several times a week should every one repair to it, in some shape or other, either at morn, mid-day, or evening, according to strength and leisure. There certainly does not exist a greater device in the Art of Living, or a greater instrument for securing a vigorous and buoyant existence. It is one of the most powerful diversions to the current of business occupation ; it can suspend for a time the pressure of our pursuits and anxieties, and return us fresh for the enjoyment of our other delights. To the three varieties of state which our bodies pass daily through, eating, working, sleeping, it would add a fourth, luxurious in itself, and increasing the relish for all the rest. It would contribute to realise the perfect definition of a good animal existence, which is, *to have the appetite always fresh for whatever is before us*. The health of the mind must be based in the first place on the health of the body ; mental occupation and refined enjoyments turn into gall and bitterness if they are not supported by the freshness and vigour of the physical frame.

The Roman multitude of the days of the empire, in their abuse of the blessing of the bath, bore testimony to the range of its power ; with them it was found capable of absorbing a man's whole existence : it consumed agreeably every part of the passing day that was not given to sleep or meals. It was made the centre of the life-system ; and all other occupations, such as gymnastic sports, conversation, reading and listening to the poets, were merely regarded as filling up the intervals of bathing. I do not think that any amount of pedestrianism, jockeyship, horse-racing, hunting, boating, cricketing, or the like could furnish out a life so complete and satisfying as the life made up at the public baths of Imperial Rome. This extreme case is to be looked on as an experiment upon the utmost power of the system. It is a convincing proof that the bathing institution may be introduced with infinite advantage as one of the standing elements of our bodily succour and support.

Before the practice of bathing can be universal, or even very general, there is much to be done in the way of supplying water in abundance to our dense populations ; indeed, the possibility of establishing the institution, with all its benefits to the full extent, must mainly depend on the success of the endeavours to accomplish this great object of public administration.